Computers in Human Behavior 30 (2014) 396–408

Contents lists available at SciVerse ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

Modeling and exploiting collaborative traces in web-based collaborative working environment

Qiang Li *, Marie-Hélène Abel, Jean-Paul A. Barthès

Université de Technologie de Compiègne, UMR, CNRS 7253, France

ARTICLE INFO

Article history:
Available online 15 May 2013

Keywords:
Collaborative working environment
Trace-based system
Collaborative trace
Collaborative engineering
Experience Management

ABSTRACT

In a Web-based Collaborative Working Environment (CWE), traces are always produced by past activities or interactions. Although every trace derives from the stored information, the modeled trace not only represents knowledge but also experience from the interactive actions among the actors or between an actor and the system. Normally, with the increasing complexity of group structure and frequent collaboration needs, the existing interactions become more difficult to grasp and analyze. This article focuses on defining, modeling and exploiting the various traces in the context of CWE, in particular Collaborative Traces (CTs) left in the shared/collaborative workspace. A model of collaborative trace that can efficiently enrich group experience and facilitate group collaboration is proposed and explained in details. Furthermore, we introduce and define a type of complex filter as a possible approach to exploit the traces. Four basic scenarios of collaborative trace exploitation are presented to describe its effects and advantages in CWE. A general model and framework of CT-based SWOT Analysis is discussed with examples. For practical applications, the validation of our model is examined in the context of the collaborative platform E-MEMORAe2.0. In addition, a remark concerning recommendations based on collaborative traces is given in the conclusion.

1. Introduction

With the rapid development of Internet and wireless techniques, collaboration is becoming much more flexible and effortless, for example: people can work together using various devices (e.g., tablets, laptops or smart phones) with less restrictions due on time, language, or geographical position. In a Web-based Collaborative Working Environment (CWE), users' actions always leave traces when users exchange messages, edit wikis or handle documents. Such traces come from past interactions and contain information (in the following, the word trace stands for interactive trace). In this paper we do not intend to enter the debate about information, knowledge and experience, but accept a common point of view found in the IT literature. Namely, information is "processed data," knowledge is "authenticated information" (Dretske, 1983; Machlup, 1984; Zins, 2007), and "experience" can be considered a special case or a refined form of knowledge at a higher level (Sun and Finnie, 2005; Schneider, 2009). In particular Clauzel and his colleagues claim that traces can be regarded as "knowledge sources" (Clauzel et al., 2011). According to Mille and his team, both user and group knowledge can be captured from the modeled traces (Champin et al., 2004). They also explain that traces from the complex tasks reflect experience more than simple knowledge (Laflaquière et al., 2006). More precisely, Laflaquière showed that almost all past interactions represent a kind of trace that can be used to measure the user's working experience (Laflaquière et al., 2006).

The research work above substantially concentrates on defining and analyzing personal traces but shows less interest for the interactive relations among collaborators. For group work, collaboration always depends on shared "Knowledge" but more precisely, it requires collaborative "Experiences." Such "Experiences" often come from past interactions. Considering Web-based CWE, building a trace model for the purpose of enriching group experience and facilitating collaboration is an interesting research issue that does not seem to have available or satisfying solutions currently. The problem involves three critical research facets: (i) definition and modeling of collaborative traces taking into account characteristics of CWE, e.g. collaboration mode or group workflow; (ii) group modeling and structure design, which is widely discussed for groupware; and (iii) exploitation and reuse of collaborative traces, e.g. producing a SWOT Analysis for group to support future decisions and planning by using collaborative traces. Indeed, in CWE, the members' or group's actions or interactions are mainly taken in the group shared/collaborative workspace. Therefore, collaborative traces are crucially important and should be studied and analyzed.

In addition, collaborative traces can be used to support awareness, which will be discussed later, although it is not our primary concern in this paper.

* Corresponding author. Tel.: +330647852289; fax: +330344234477.
E-mail addresses: liqiang@utc.fr (Q. Li), marie-helene.abel@utc.fr (M.-H. Abel), barthes@utc.fr (Jean-Paul A. Barthès).

0747-5632/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.chb.2013.04.028

In this article, we follow the definition that we have already proposed (Li et al., 2012b) and introduce a more general model of collaborative trace, based upon a model of group. In addition, several fundamental scenarios for collaborative traces exploitation and reuse are explained with respect to Experience Management Theory.

The next section revisits the definition of trace (interactive trace) from the scientific literature. Then we present our model of collaborative trace using a practical example. Principal comparisons among models of trace are listed in order of importance. After that we give an example of the process of trace exploitation, applying our model to the E-MEMORAe 2.0 collaborative environment. Then we end the paper with final conclusions and perspectives.

2. Definition of trace

The concept of trace appears in different contexts with various definitions, for example, trace is related to a square matrix or a linear transformation in mathematics, and it can also mean a history carried by a sign in semiology. The etymology of this term (noun form) can be found in the old French "Trace" and its basic meaning is "path that someone or something takes"[1] (Middle English). It is now completely defined as "a mark, object, or other indication of the existence or passing of something,"[2] for example: animals' footprints. In this sense, trace is strongly affected by the existent "environment" and the subject's "actions." It naturally represents a series of interactions between the subject and the coexisting environment associated with some index, e.g. time. As an extension of this connotation, in computer science, a trace usually concerns the interactive activities between the system and the actors.

Many researchers proposed definitions of traces[3] in different research projects. The MUSETTE approach (Modeling USEs and Tasks for Tracing Experience) was proposed by Mille and his colleagues in 2003 with the objective to "capture a user trace according to a general use model describing the objects and relations handled by the user of the computer system" (Champin et al., 2003). Through MUSETTE, the trace is treated as "a task-neutral knowledge base" that can be reused by the system assistants. Moreover, from the illumination of Sun's work on the theory of Experience Management (Sun and Finnie, 2005), they proposed another approach "Trace-Based Management Systems (TBMSs) (systems devoted to the management of modeled traces)" (Laflaquière et al., 2006) to analyze and model personal interactive traces. A general framework was introduced to support trace-based system creation and experience reuse. In this case, a trace is defined as "temporal sequences of observed items." Recently they built a platform to represent the activities as a set of observed elements: a kernel for trace-based systems.[4] For kTBS, a trace is defined as a container of observed elements. Nevertheless, this platform is currently only a prototype. With minor variance, Clauzel and his colleagues defined an interaction trace as: "histories of users' actions collected in real time from their interactions with the software" (Clauzel et al., 2009). They also talked about "Synchronous Collaborative Traces," but without further discussing the definition. More directly, Zarka and his colleagues defined a trace of interaction as "a record of the actions performed by a user on a system, in other words, a trace is a story of the user's actions, step by step" (Zarka et al., 2011). In a different way, Settouti and his colleagues define a numerical trace as a "trace of the activity of a user who uses a tool to carry out this activity saved on a numerical medium" (Settouti et al., 2009). In the TRAIS project (Personalized and Collaborative Trails of Digital and Non-Digital Learning Objects),[5] a trace is analyzed in hypermedia as a sequence of actions and is used to identify the users' overall objective.

Considering the principal characteristics of collaborative working environment, especially, a web-based CWE, a trace not just records the interactions between user and system but also reflects the potential relationships among collaborators. From this point, we distinguish different types of traces and focus on the definition of a Collaborative Trace (CT) defined as follows: "A Collaborative Trace is a set of traces that are produced by a user belonging to a group and is aimed at that group" (Li et al., 2012b). The following section introduces a model of collaborative trace together with some basic notations.

3. Modeling collaborative traces

Collaboration is the action of working jointly with someone to produce something.[6] The development and progress of human society cannot maintain and advance without 'collaboration'. Especially, the evaluation of tool imperceptibly affects and changes our behaviors and habits of collaborating. Decades ago, with the popularity of computer and invention of Internet, mankind collaborative work is freed from the limitations of time, languages, or geographical positions. As we know, a web-based platform can be used as an ideal object to support both personal and collaborative work using a variety of devices.

Our model is based on a typical Web-based Collaborative Working Environment (WCWE).[7] The term "CWE" comes from the utilization of collaborative software in a shared workspace. In the software engineering area, usually, collaborative activities can be separated into four categories: "Mandatory, Called, Ad hoc, and Individual" (Robillard and Robillard, 2000), for instance: video conference, e-mail, group wiki or document management and so on. And almost all the collaborative activities happen in the group shared work space. Any finished interactions or actions that rely on the functionalities in the shared space can be characterized by the modeled traces. Compared with the trace model proposed by Clauzel et al. (2011), our model focuses on the interactions among the actors themselves, in the context of classification and comparison of different types of traces. The trace model that was applied in the project ITHACA (Clauzel et al., 2009) is similar to the model found in the platform kTBS.[8] They both tightly depend on the research of trace-based management systems (particularly, the general framework of TBMS). Lafifi and his team proposed a different trace model (Lafifi et al., 2010) applied in their approach SYCATA in which they concentrated on the architecture of the collaborative learning system. In a different approach, the model introduced by Sehaba (2011) deals with the transformation process for the adaptation of the shared traces in accordance with the user's profile.

Following the definition of CT proposed in Li et al. (2012b) we first introduce a simple example before explaining our model. Suppose that, in a certain WCWE, some engineers are collaborating for a project in different countries. Julien, one of them, sends a mail to his colleagues, Pierre and Yves, about a technical problem. At the same time, he edits his personal wiki concerning this issue. Pierre finds that the question is meaningful and crucial for designing their product. So he proposes to hold a video conference to discuss possible answers to some of the questions, by sending a mail, then he posts a message to the group. Furthermore, he adds an entry in the

[1] Oxford Dictionaries Online: http://oxforddictionaries.com.
[2] Oxford Dictionaries Online: http://oxforddictionaries.com.
[3] In this paper, unless annotated in particular, no differences are among trace, interaction trace and trace of interaction.
[4] kTBS platform: http://liris.cnrs.fr/sbt-dev/ktbs.
[5] http://www.noe-kaleidoscope.org/telearc/.
[6] Oxford Dictionaries Online, 2012, http://oxforddictionaries.com.
[7] In this article, we do not make a difference between Web-based Collaborative Working Environment (WCWE) and Collaborative Working Environment (CWE) unless explained in particular for the Web-based condition.
[8] https://kernel-for-trace-based-systems.readthedocs.org/en/latest/.